Nantucket Harbor Water Quality
2002 Annual Report

Prepared for:
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Executive Summary

Nantucket Harbor is well mixed and has good water quality most of the year. Tidal exchange, wind, and water density permit mixing of surface water with bottom water. During the summer, anoxic and hypoxic pockets occur in Head of Harbor and Quaise as temperature and oxygen separates the water column. Nutrient inputs from the watershed as well as internal recycling during low oxygen event upset the natural water chemistry balance inside the harbor. The Head of the Harbor is eutrophic in February and May based on total nitrogen. The Head of the Harbor is eutrophic in May, June, August, and November based on total phosphorus. Increased nutrient concentrations change the physical environment for phytoplankton, macro algae and fish populations. Unpredictable and rapid changes in nutrient concentrations can result in stressed organisms. These changes give reason to be concerned about water quality conditions in Nantucket Harbor.

In 2001, the Division of Marine Fisheries has placed additional shellfish closures on Polpis Harbor and the lower Harbor as a result of elevated fecal coliforms. Fluffy organic sediment caused by decaying organics is the ideal environment for fecal coliforms to flourish. The nitrogen entering the harbor through the watershed provides the food source for fecal coliforms to reproduce.

Nantucket Sound has good water quality by nitrogen concentration standards. Nantucket Sound ranged from 50ppb to 72ppb in 2002. The average total nitrogen in Nantucket Sound was 33ppb. The average nitrogen concentration inside the harbor was 34.2ppb representing good water quality based on total nitrogen. Polpis Harbor averaged 41.3ppb for the year. This concentration falls into the moderate water quality classification. Dissolved oxygen and secchi depth in Polpis Harbor is reflective of moderate water quality conditions.

Since 1997, there does not appear to be a trend toward higher nitrate concentrations over time. However, Nantucket Harbor contains more nitrogen than it should. Nitrogen is found in the highest concentration in the Head of Harbor indicating internal recycling and watershed contributions. This year nitrate concentrations were low. The change in water chemistry could be a result of atmospheric conditions. However, the number of yachts and boaters decreased from 2001 reducing the volume of grey water discharged into the harbor. The weather was dry reducing stream flow inputs from the watershed. Public education of proper lawn care practices may have had a positive affect in the watershed.

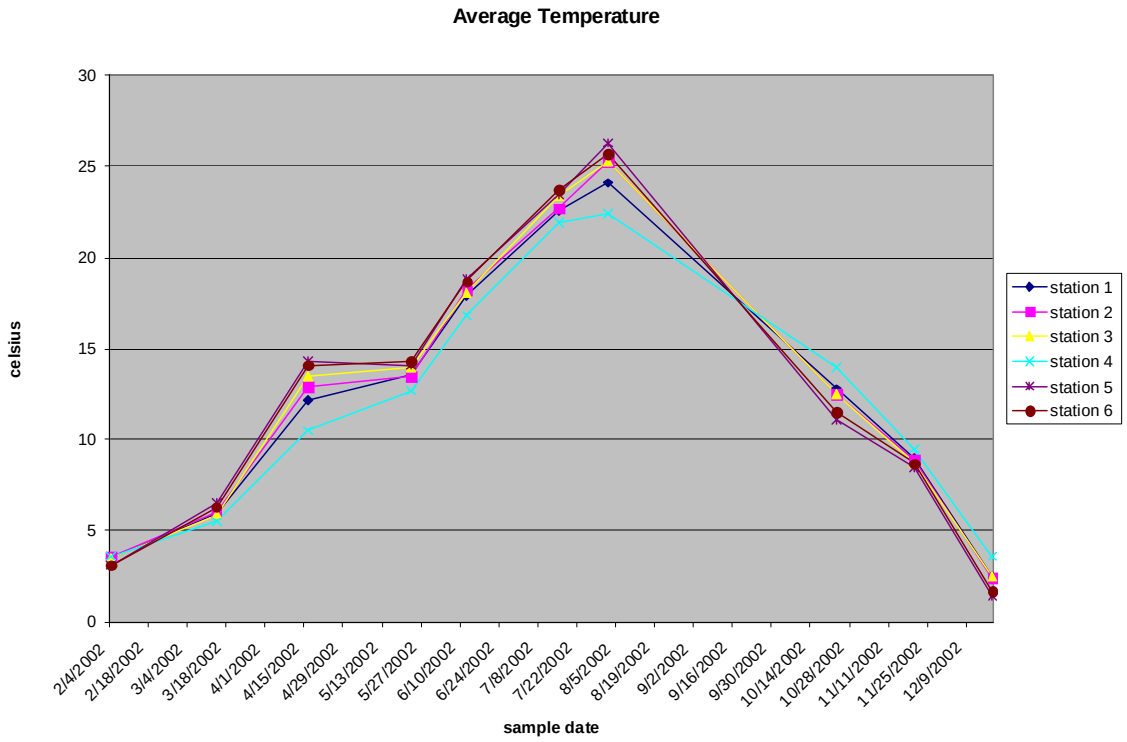
Phosphorus is more conservative than nitrogen. Phosphorus is therefore more reflective and informative as to the processes going. Phosphorus concentrations are alarming. Data suggests more phosphorus is from the watershed as well as from Nantucket Sound. There has been a substantial increase in phosphorus concentrations in the harbor over the last five years. Phosphorus is higher at station 1 most probably due to storm drains. Phosphorus could also be a result of increased sedimentation from the high speed ferries, gray water, and or fertilizer application. Phosphorus is increasing in the town/mooring field area.

Changes in the nitrogen/phosphorus ratio result in increased organics in the water column. Physical changes can be observed such as organics coating shellfish flats, i.e. Pocomo.

Harbor Monitoring Results:

Nantucket Harbor:
The average water temperature for six harbor sites is depicted in Figure 1. The Head of the Harbor retains water for longer periods of time allowing the greatest temperature difference in temperature from surface to bottom. A weak thermocline was observed in April at the Quaise Basin. The mooring field station most closely resembles Nantucket Sound. Polpis Harbor is shallow. Polpis warms and cools faster than the rest of the harbor.

FIGURE 1



The bay scallop spawn when water temperatures increase from 68F (20C) to 72F(22C). The combination of age, phytoplankton concentration, and water temperature cause bay scallops to spawn at different locations at different times. Based on the recorded water temperature only, the mature scallops in the head of the harbor and Pocomo area should have spawned first followed by the lower harbor. The first spawn took place in the later

part of June. Due to the slower warming water temperatures of Nantucket Sound, bay scallops outside Nantucket Harbor theoretically should spawn last. A second spawning event took place in mid September. Water temperatures permitted scallops to continue to grow through the end November into early December this year.

FIGURE 2

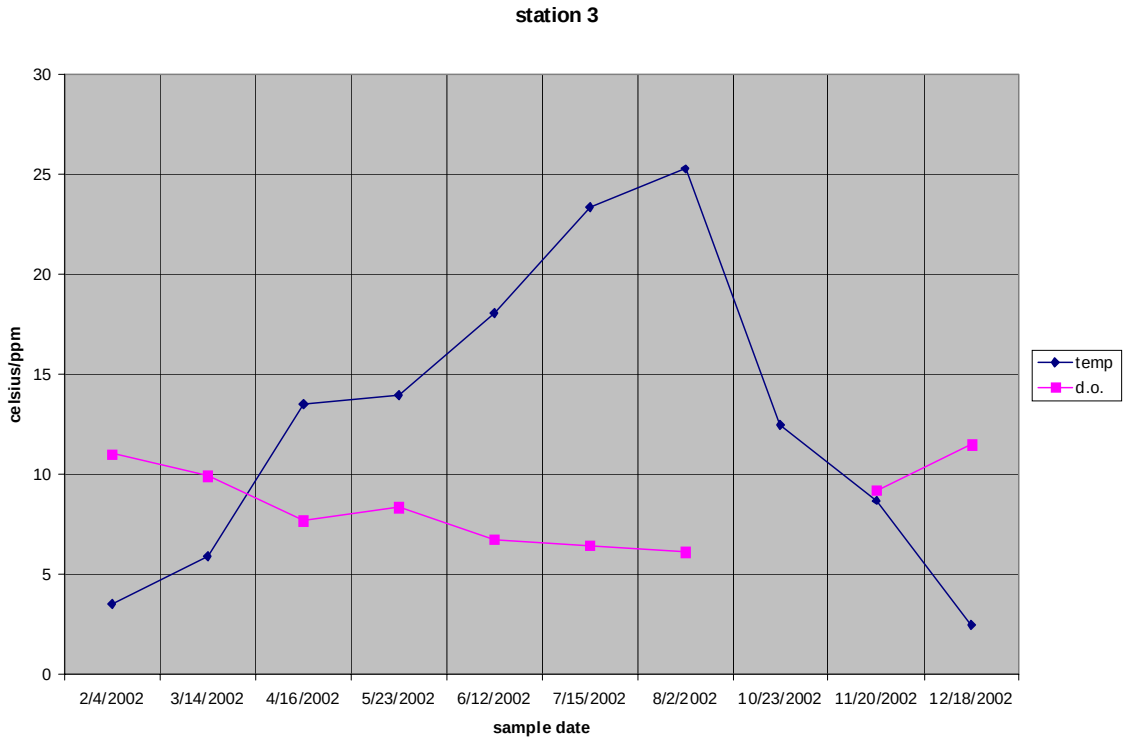


Figure 2 demonstrates the inverse relationship of dissolved oxygen to water temperature in the Head of the Harbor. As water temperature increases in summer, dissolved oxygen declines. The Head of the Harbor had the highest water temperatures after Polpis Harbor sites.

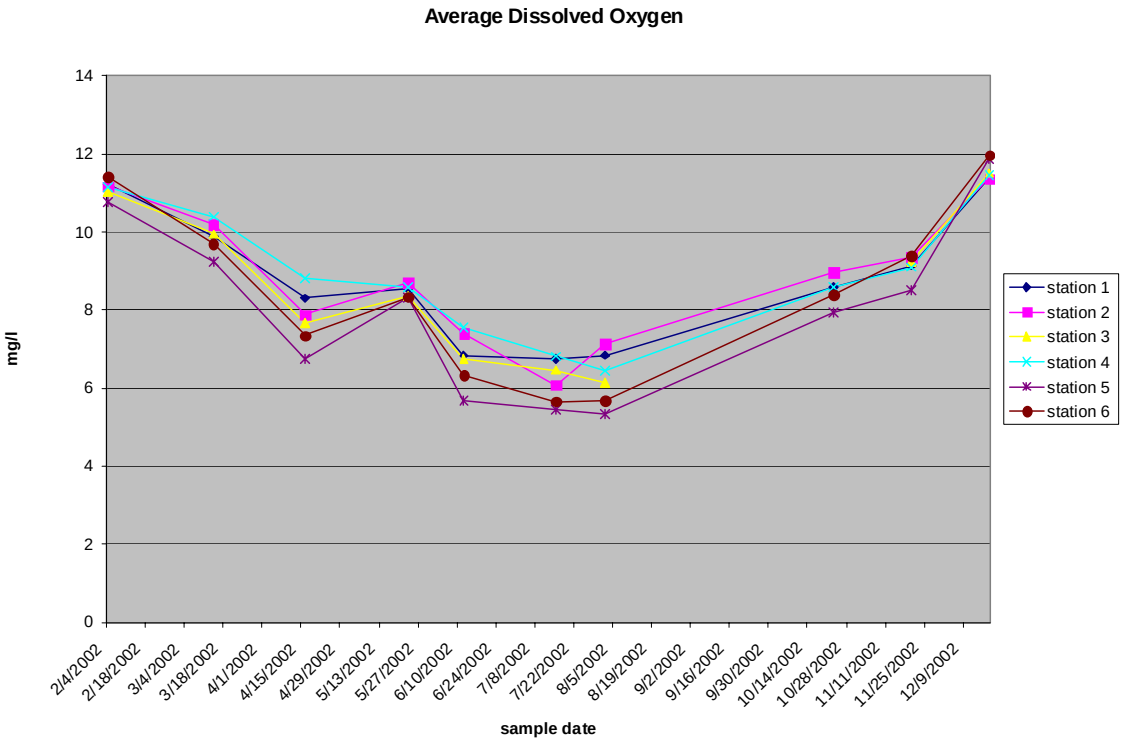
Salinity

Salinity was the highest in Nantucket Sound ranging from 32.3ppt to 32.8ppt. Mooring field's salinity range was 31.9ppt to 32.5ppt. Quaise ranged from 31.4ppt to 32.8ppt. Head of Harbor ranged from 31.6ppt to 32.4ppt. Polpis East salinity ranged from 30ppt to 32.4ppt. Polpis West ranged from 30.2ppt to 32.7ppt.

Salinity changes due to circulation in combination with precipitation, stream contributions and groundwater. Salinity will also change at surface due to evaporation during warmer months. The salinity only differed by 2ppt generally in the coarse of a year.

Dissolved Oxygen:
On average, dissolved oxygen concentrations in the harbor were slightly below Nantucket Sound until July. In August, the Quaise and Mooring Field sites had higher oxygen concentrations than Nantucket Sound. Dissolved oxygen concentrations were higher in the winter and fall due to cooler water temperatures. During February, March and April dissolved oxygen was super saturated in the water column. As the water temperature warmed in the spring and summer, dissolved oxygen was lost in the bottom layer of water. Polpis West, station 5, had the lowest overall dissolved oxygen.

FIGURE 3

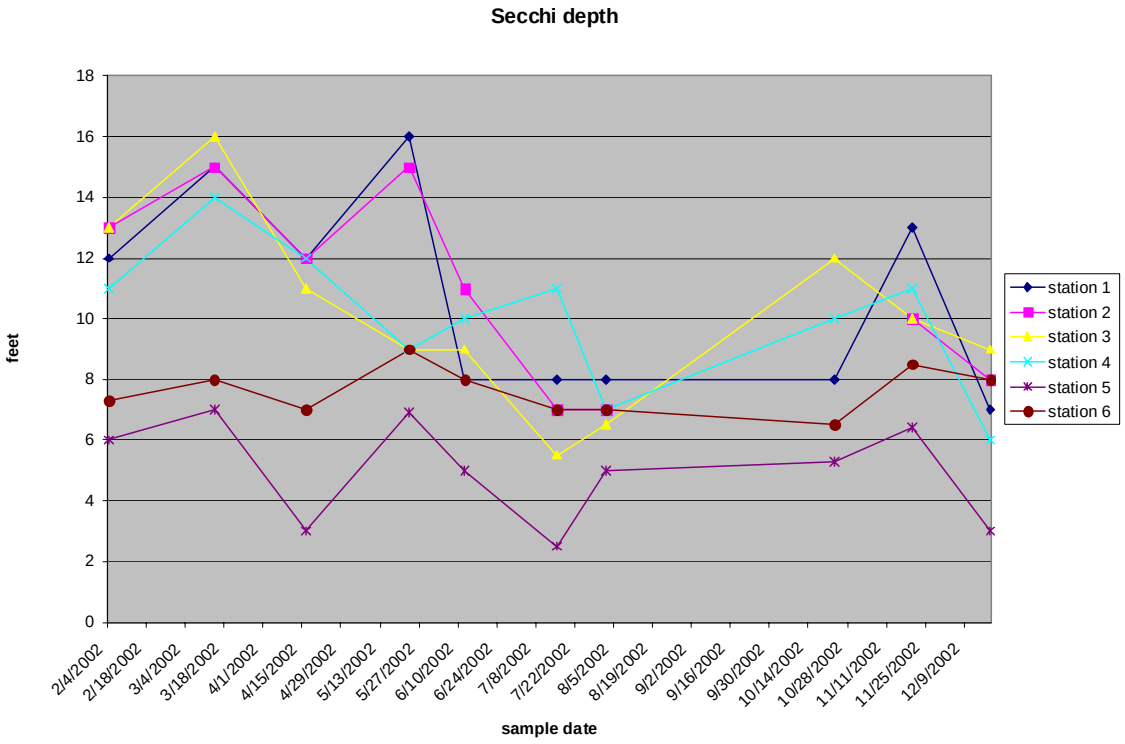


Secchi depth

Secchi depth is an approximate measure of water transparency or water clarity. Secchi depth is an estimate of the quantity of particulate matter, (phytoplankton and organics) suspended in the water column. Greater water clarity will result in greater secchi depths. Secchi depth is a good estimate of the density of phytoplankton populations. Secchi depths were recorded for each site monthly.

The secchi depths were good this year. Polpis West had the lowest secchi depths for all sites sampled. Wauwinet had low secchi depths in July and August.

FIGURE 4



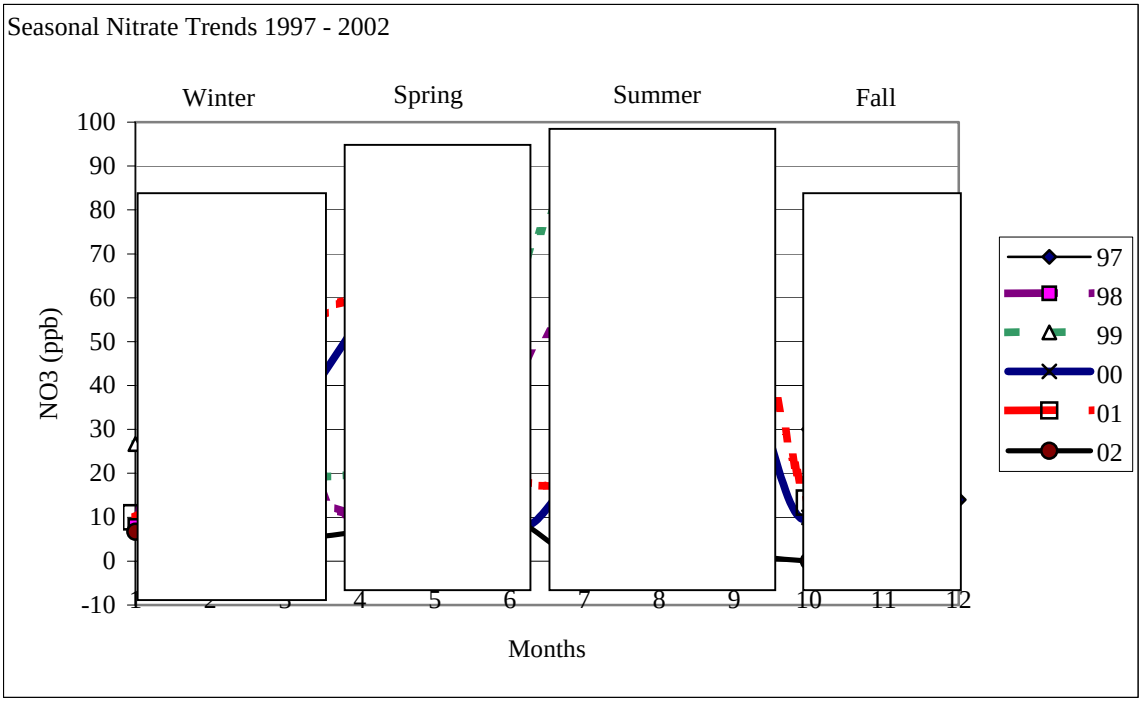
Nutrient

Nitrogen occurs in three major forms in aquatic environments (ammonia, nitrate and organic compounds). Nitrite is a fourth form; but due to its instability it exists for very short periods of time during the conversion between other forms.

Nitrate is an inorganic component of nitrogen. Nitrate is readily available for uptake of phytoplankton. In large concentrations, nitrate can cause phytoplankton blooms and impair water quality. As nitrate levels increase, phytoplankton, macroalgae and epiphytes reproduce. High concentrations of nitrate in the water column select the growth of more invasive plant species. These less desired plants eventually replace eelgrass beds.

Nitrate appears to peak twice per year in Nantucket Harbor. The first peak occurs either in winter or spring and the second peak in the summer. The first peak generally originates from the Sound and coincides with a diatom bloom.

FIGURE 5

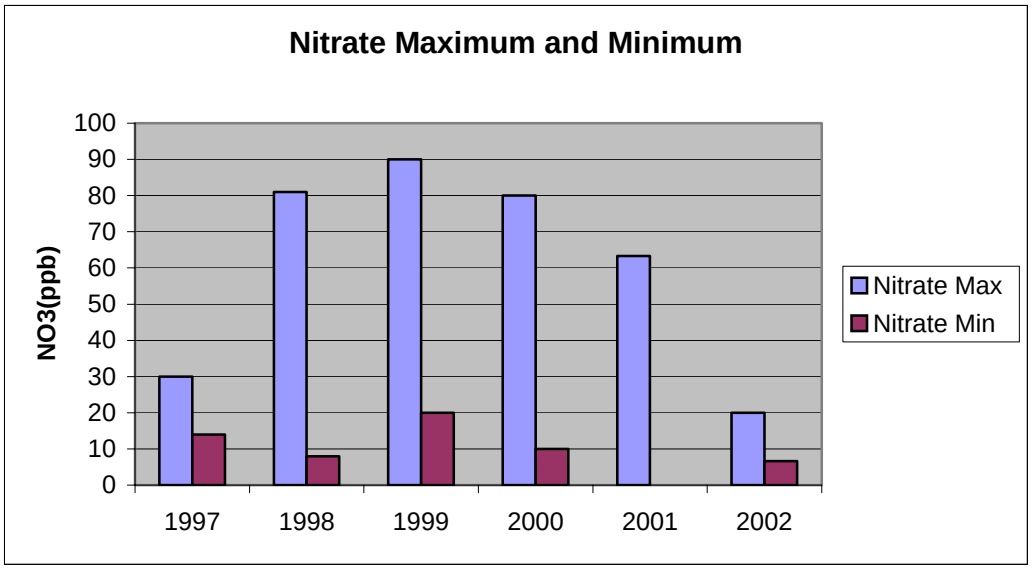


To compare changes in water quality inside the harbor, Nantucket Sound is considered baseline or background. Nantucket Sound ranged from 50ppb to 72ppb in 2002. The average total nitrogen in Nantucket Sound was 33ppb. This concentration represents good water quality.

The average nitrogen concentration inside the harbor that includes Mooring Field, Quaise, and Wauwinet was 34.2ppb. This also represents good water quality based on total nitrogen. Polpis Harbor averaged 41.3ppb for the year. This concentration falls into the moderate water quality classification based solely on total nitrogen concentrations. Dissolved oxygen and secchi depth in Polpis Harbor is reflective of moderate water quality. Nantucket Harbor is eutrophic in May and June based on total nitrogen.

Since 1997, there does not appear to be a trend toward higher nitrate concentrations over time, Figure 6. Nitrate concentrations, which exceed 60ppb, are excessive. This year nitrate concentrations were low. The change in water chemistry could be a result of atmospheric conditions or the lessened anthropogenic inputs from a depressed economy.

FIGURE 6:



The greatest concentration of nitrogen was found in the total organic form. Nitrogen was the highest at the head of the harbor. Nitrogen appears to be recycling internally as well as entering through the watershed. Nitrogen watershed pathways include fertilizer and septic systems. Nitrogen observed in Polpis Harbor reached impairment levels during the summer. Nantucket Sound had a spike in nitrogen in June.

Nantucket Harbor contains more nitrogen than it should. Nitrogen is entering the harbor and increasing the nitrogen/phosphorus ratio. The observed N/P ratio in 1993 was recorded at approximately 3. In 2001, the N/P ratio has increased in some area to 10. Nitrogen vacates Nantucket Harbor with each tidal cycle. However, nitrogen is added to the system through its watershed.

Phosphorus has increased dramatically in Nantucket Harbor over the past two years. The trend in maximum and minimum phosphorus concentrations have increased since monitoring in 1997, Figure 7. Phosphorus concentrations, which exceed 50ppb, are excessive in a marine system. Phosphorus appears to be originating at some level in the mooring field and Quaise stations in May. Sources of phosphorus could be via storm drains, fertilizer use, marine activities (detergents, soaps) in mooring field, and/or increased sedimentation from the fast ferries and stream contributions. All streams contained phosphorus in elevated concentrations in May. Streams 3, 4 and 8 contained phosphorus in high concentrations for the majority of sample dates. This phosphorus then radiates to the head of harbor.

FIGURE 7

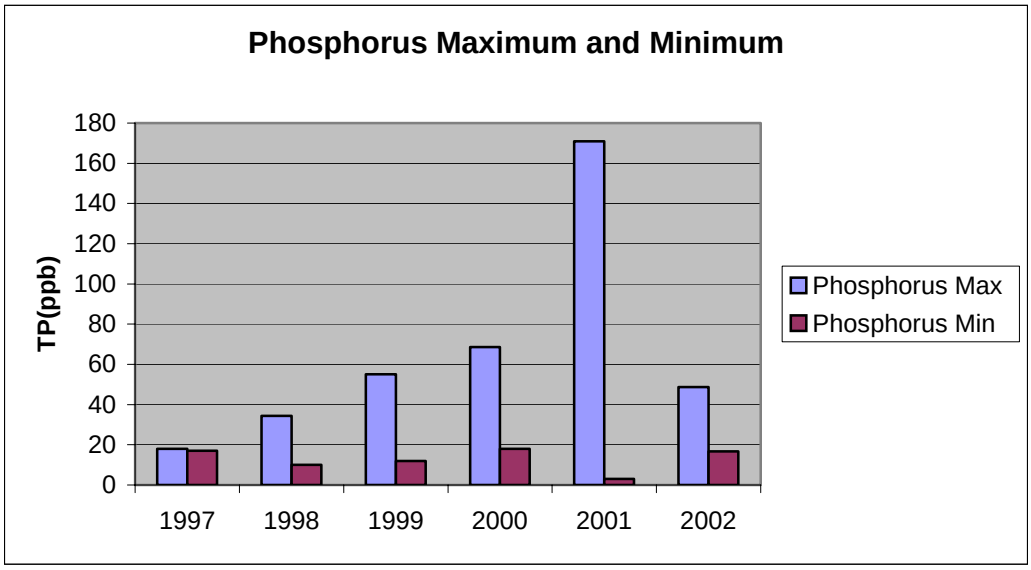
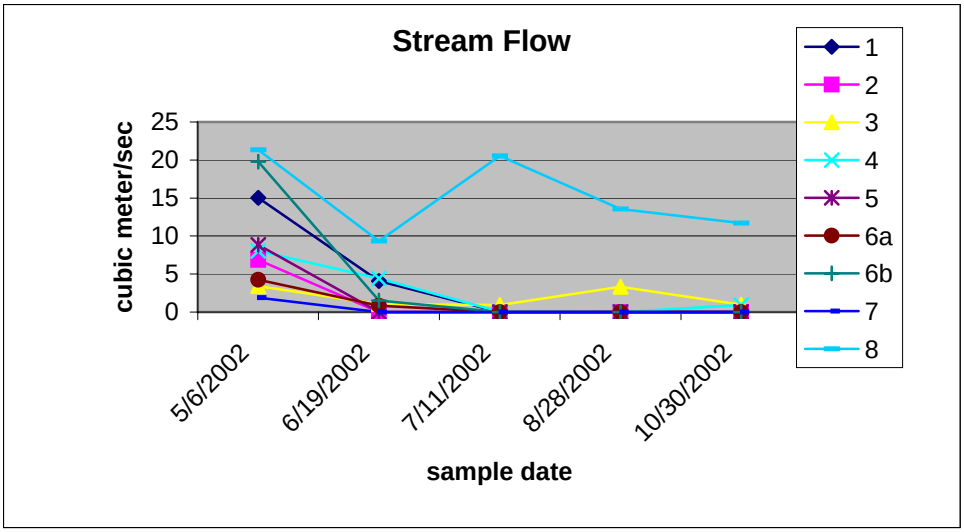


Figure 8



Eight streams were monitored for temperature, dissolved oxygen, salinity, conductivity, velocity, flow, nitrate, ammonium, total organic nitrogen, total nitrogen, and total phosphorus. A description of the stream locations are as follows: stream 1 flows into head of harbor; stream 2 flows into Meadowi Creek; stream 3 flows into Polpis East; stream 4 drains the cranberry bogs and flows into Polpis East; stream 5 drains swamp near cemetery and flows into Polpis West; stream 6a and 6b flow into Polpis West; stream 7 flows into Quaise; stream 8 drains Folgers Marsh and adjacent wetland near Life Saving Museum.

All of the streams contained nitrogen and phosphorus in May, Figures 9 and 10. Stream 1 had high concentrations of nitrogen, 10mg/sec in May. Stream 3 carried both nitrogen and phosphorus to Polpis Harbor for all sample dates. Stream 4 contained nitrogen and phosphorus for four out of five sample dates. Although stream 4 had the highest flow rate and contained nutrients, this stream was not the greatest nutrient contributor. Stream 6b contained high nitrogen, 0.012mg/sec in May. Stream 6b contained high phosphorus, 0.002mg/sec in May. During July, August and October, only three streams flowed into the harbor carrying nitrogen and phosphorus. The remaining streams were dry. All streams contained high levels of organic nitrogen and some concentrations of ammonium when flowing. Stream 8 had consistently high nutrient concentrations this year and was the largest nutrient contributor to the harbor.

FIGURE 9

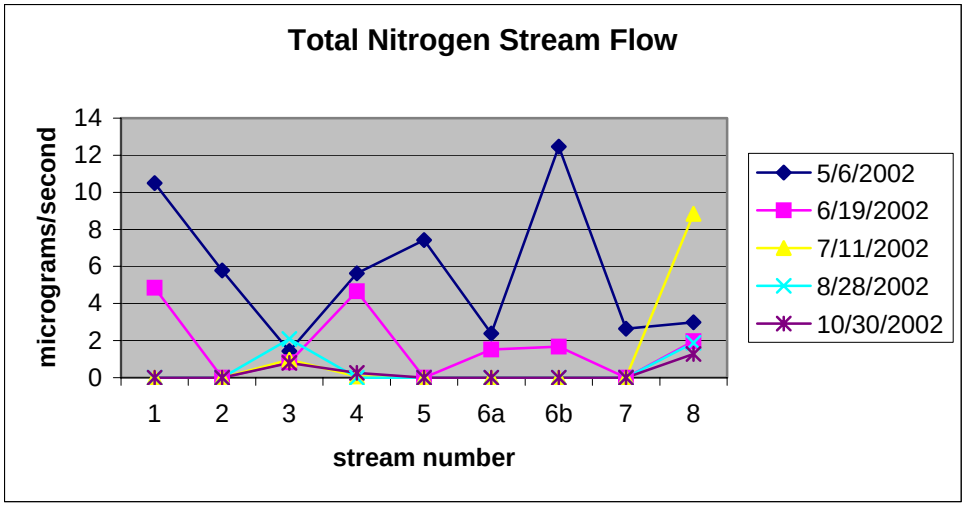
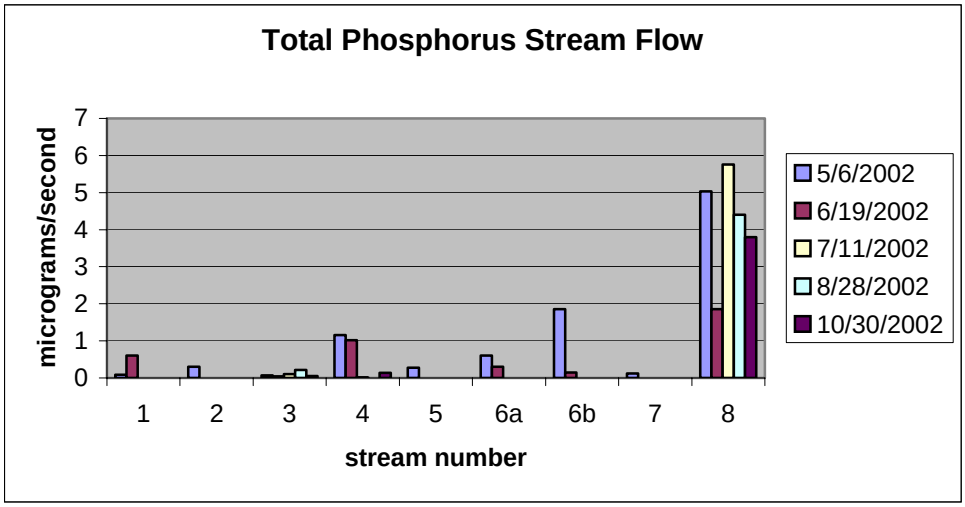


FIGURE 10



CONCULSIONS

1. Nitrate peaks twice per year
2. Nitrate does not appear to be increasing over time
3. Nitrogen is found in highest concentration in Head of Harbor due to watershed input and internal recycling
4. Changes in the nutrient ratio result in changes in phytoplankton communities
5. Phosphorus is increasing over time
6. Phosphorus is originating in the mooring field area and radiating throughout harbor
7. Phosphorus and nitrogen concentrations in streams are in high in May
8. Stream 8 was the largest watershed nutrient contributor this year
9. Water quality was better this year probably due to atmospheric condition and or improvements in land use in watershed
10. Nantucket Harbor water quality is moderate 30% of the time and eutrophic 10%
11. The head of the harbor is eutrophic 16% of the time